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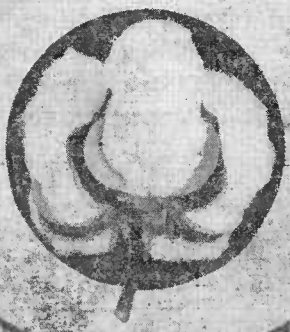
COTTON IMPROVEMENT UNDER WEEVIL CONDITIONS



SINCE ITS ENTRANCE into the United States from Mexico in 1892 the boll weevil has been spreading rapidly throughout our cotton-growing area, until to-day only the extreme western and northern sections of the main cotton belt remain uninvaded.

The losses to the cotton industry of this country through the ravages of this insect amount to hundreds of millions of dollars annually.

At first, it was feared that only the earliest and most inferior varieties of cotton could be grown in the presence of this pest, but it has been found that the boll-weevil invasion not only will not prevent the improvement of the cotton crop but affords additional reasons and opportunities for such improvement.

Through better organization of cotton-growing communities and improved cultural methods it is possible to grow early varieties with longer, more abundant, and uniform fiber, for which better prices may be secured, and thus offset the losses inflicted by the weevil.

Contribution from the Bureau of Plant Industry.

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COTTON IMPROVEMENT UNDER WEEVIL CONDITIONS.

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AT FIRST it was feared that only the earliest and most inferior varieties of cotton could be grown in the presence of the boll weevil and that the presence of the weevil must result in a general deterioration of the crop, as well as in reduced production. These apprehensions appeared to be justified in the earlier years of the weevil invasion, because it was found that the crop had to be set in a much shorter period of time if weevils were present, and late varieties could no longer be grown. Nevertheless, it was found possible to develop early varieties with longer, more abundant, and more uniform fiber, and to hasten the setting of crops through improved cultural methods. The requirement of earliness remains important, but no longer interferes with the improvement of the crop as raised under weevil conditions.

Instead of being satisfied with an inferior crop, farmers should understand and take advantage of the possibility of increasing the value of their cotton by planting better varieties, which is now to be considered as a form of protection against unnecessary losses from the boll weevil. With the varieties and the cultural methods improved, it is possible to produce long-staple cotton in many districts where only short-staple types were grown in the past. The cost of production need be no greater with long-staple varieties than with short, except that more care is needed in handling the crop and maintaining supplies of pure seed. Every advance of a cent a pound in premium means an increased profit for the farmer of about $5 a bale. Premiums of 3 or 4 cents a pound double the farmer's profit.

Premiums from 5 to 10 cents, which often are paid for long-staple cotton, represent differences of from $25 to $50 in the value of each bale.

The fact that the old late-maturing long-staple types often failed to mature their crops and are not adapted to weevil conditions should not be allowed to obscure the fact that earlier long-staple varieties have been developed, varieties that have the same habits of growth as ordinary short-staple varieties, but which produce a longer fiber. Ideas that have been carried over from experience with the late-maturing long-staple varieties of former decades still keep many farmers from understanding the advantages that may be secured from the use of the earlier long-staple varieties, even in regions that are known to be suited to the production of long-staple cotton. The breeding and distribution of earlier and more prolific types of long-staple cotton by the United States Department of Agriculture must fail of their full possibilities of value unless the cotton-growing public becomes aware that such varieties are capable of much more general utilization.

The substitution of eastern small-boll varieties in Texas and other weevil-infested regions was urged by seed dealers until it was found that the extra-early small-boll varieties had no real advantage over the Texas big-boll type. Some advertisers even went so far as to claim that all cotton seed raised under weevil conditions was inferior, in the hope that farmers in weevil-infested districts would continue to buy seed from the Atlantic States, but such ideas have been discarded after more extended experience with the boll weevil.

RELATION OF IMPROVEMENT TO FOREIGN COMPETITION.

If the boll weevil inflicted a general deterioration in the quality of the fiber, in addition to the damage done by reducing the yield and increasing the cost of production, the American farmer would be placed at a much greater disadvantage in relation to foreign competition. Very active efforts are now being made to establish or to extend the production of cotton in many foreign countries. Though such efforts in the past did not result in serious injury to the cotton industry of the United States, every season of high prices stimulates greater activity in other countries. Disturbed conditions resulted in the suspension of some of these efforts during the war period, but there is every probability that much more important centers of cotton production will be developed in other parts of the world within the next few years if the present high prices continue.

Many representatives of foreign governments have come to the United States to study the American cotton industry in the last few years, from Russia, China, Japan, India, the British colonies in

Africa, Brazil, Argentina, Peru, and other countries. Foreign governments are also employing American experts and are purchasing supplies of seed of the improved varieties that have been bred by the United States Department of Agriculture. Large quantities of seed of the Columbia, Durango, Trice, Lone Star, and other varieties have been shipped abroad, although our own stocks of pure seed still are inadequate.

The effect of such competition is likely to be felt first by the producers of low-quality short-staple cotton. Indeed, our own manufacturers had begun to import inferior cotton from India and China before the war. It may be that such importations will not be resumed or become a regular custom, but in any event they call attention to the fact that fiber of inferior quality is already produced in foreign countries more cheaply than in the United States. Disregard of quality has even been carried to the extent of planting varieties with extremely short or irregular fiber, of little value for textile purposes, such as the so-called Half-and-Half cotton, which farmers have been warned not to grow, because of market discrimination against it.

Fortunately, we are not limited to the production of inferior fiber even in the presence of the boll weevil. Instead of preventing the use of improved varieties of cotton, the boll-weevil invasion makes the improvement of varieties still more important than before. That the weevils make it necessary for farmers to adopt better methods of preparing and cultivating the land represents a more favorable condition for the production of superior fiber. The same precautions that are necessary to secure a crop in the presence of the weevil make it possible to produce fiber of better quality.

A SHORTER SEASON FOR THE COTTON CROP.

A general result of the weevil invasion is to shorten the fruiting period of the cotton crop. Except in rare cases where severe drought keeps the weevils from breeding, there is no such thing as a late or "top crop" in weevil-infested regions. Before the weevils came it was almost a matter of indifference to the farmer whether the first of the flower buds remained on the plants and developed into bolls or were blasted and shed. The shedding of the early buds is a frequent result of the unfavorable conditions that make the growth of the plant irregular. The cotton plant nearly always produces a superabundance of buds, several times as many as can be brought to maturity. With other plants that produce flowers for only a few days, a short period of unfavorable weather may mean the loss of the whole season's crop, but the cotton plant blossoms all summer and can recover from many setbacks unless the weevils interfere. It was

this power of recovery that made cotton a sure crop and allowed the system of credit farming to be built up.

As the bolls produced in the first part of the fruiting season are likely to constitute the entire crop in any weevil-infested region, it becomes of the utmost importance to understand how a large crop of bolls can be produced in the shortest possible time after the fruiting season begins.

Most of the weevils are bred in the flower buds. As soon as the first flower buds are formed the weevils begin to multiply. Then commences the race between the cotton and the weevil. The success of the crop does not depend so much upon getting a few flowers or open bolls at early dates as on getting the largest possible crop in the shortest possible time after the plants begin to produce flower buds.

With no handicaps from unfavorable weather or soil conditions, the cotton usually has an advantage at first and is able to set a crop unless the overwintered weevils are exceptionally numerous. As long as the cotton can produce buds and bolls faster than the weevils can destroy them, the setting of a crop continues. But if the cotton receives a setback and sheds the early buds or young bolls after the weevils have begun to multiply, there may be no way to retrieve the misfortune. The success of the plan of avoiding the weevil injury by shortening the growing season depends very largely on this possibility of holding the first crop of buds and bringing them through to maturity as bolls.

Owing to the fact that only a small proportion of the weevils survive the winter the pests are usually not numerous in the first part of the season, so that most of the early buds escape injury. If all the early buds were brought to maturity as bolls a good crop would be secured, even though no more bolls developed afterwards. The extent of weevil injury does not depend alone upon the abundance of the insects. External conditions of climate and soil that influence the behavior of the plants, especially in the early part of the season, determine in large measure the success or failure of the crop. The protection of the plants against other unfavorable conditions is a very large factor in the campaign against the weevils. The shorter the season can be made, the more effective are all other measures of weevil control, even including the use of arsenical poisons, which recently has been found practicable under certain conditions.[1]

Another important reason for shortening the cotton season is to enable the stalks to be removed from the fields early in the fall. If it were possible to have all the cotton picked early and all the stalks and unripe bolls destroyed, the weevils would no longer be a serious

[1] Coad, B. R., and Cassidy, T. P. "Cotton boll weevil control by the use of poison." U. S. Dept. Agr. Bul. 875, 31 pp. 1920.

menace. Early destruction of all the cotton plants leaves the pests without food or breeding places in the autumn, so that most of them are unable to survive the winter.[2]

PROTECTING THE EARLY BUDS AND BOLLS.

The value of deep plowing, frequent cultivation, and other improved cultural methods recommended for weevil conditions lies very largely in the fact that these methods serve to protect the plants against drought or sudden changes of soil conditions that would cause the blasting or shedding of the early buds and bolls. Weevil injuries are avoided indirectly by protecting the plants against other unfavorable conditions.

The shedding of the buds and young bolls from other natural causes has to be guarded against, as well as the shedding caused by weevil infestation. Farmers who have paid little attention to the natural shedding in the past are likely to consider all the fallen squares as the result of weevil injury. The damage done by the weevils in the early part of the season is often much less than is caused by unfavorable conditions. Indeed, the weevils would seldom be considered destructive if they worked only in the early part of the season. Many of the early buds and bolls are usually lost by natural shedding. The destructive power of the weevil lies very largely in the fact that it does not permit these early losses to be replaced by the setting of a later crop.

The improved cultural methods are of the most obvious advantage in dry regions, where they often enable the cotton to continue its growth during periods of drought that interfere with the breeding of the weevils. But even without such a handicap the weevils are seldom able to effect any complete destruction of the crop unless the early buds or bolls are lost through other unfavorable conditions. When the weevils survive the winter in unusually large numbers they may be able to infest all the early buds, but this does not occur very often. In some cases observed in Texas the infestation of all the early buds did not result in a total loss, for most of the weevils disappeared during a subsequent period of dry weather, thus allowing a crop to be set.[3]

In other parts of the cotton belt, where there is less prospect of the weather becoming dry enough to interfere with the breeding of the weevils, it is quite as important to observe all the cultural precautions for preserving and bringing to maturity the first crop of buds and bolls. The value of more thorough tillage is not so ob-

[2] Hunter, W. D. The boll weevil problem, with special reference to means of reducing damage. U. S. Dept. Agr., Farmers' Bull. 848, 40 p., 6 fig. 1917.

[3] Cook, O. F. Relation of drought to weevil resistance in cotton. U. S. Dept. Agr., Bur. Plant Indus. Bul. 220, 30 p. 1911.

vious or so well appreciated in the more humid regions, though there is the same necessity of maintaining uniform soil and moisture conditions and thus securing an uninterrupted development of the plants. On account of the less favorable soil conditions found in many humid districts the cotton is more likely to be injured by brief periods of dry weather not severe enough to interfere with the multiplication of the weevils. The more humid the climate the smaller are the chances that the weevils will receive a setback from drought, which often allows a later crop to be set in a dry region.

The advantage that comes from picking up and destroying the weevil-infested buds also depends very largely on whether the plants are able to make uninterrupted growth and get their crop set before later generations of weevils appear. Great diversity of opinion exists regarding the value and practicability of this measure, probably because the benefit depends on other conditions. In a field where the cotton has an uninterrupted development there may be a good crop, even though the squares are not picked up. In another field where the squares have been picked the crop may fail, nevertheless, if the weather or the soil conditions cause the plants to shed their buds and young bolls. Similar diversity of results may be expected in the control of weevils by poisoning. A treatment that may save the crop from the weevils under one set of conditions may prove entirely ineffective in another season or in another place where the weather or the soil does not allow the plants to set a crop, although the weevil population may be reduced.

DIFFERENT KINDS OF EARLINESS IN COTTON.

The importance of earliness as a means of avoiding weevil injury is now generally appreciated by the cotton-growing public, but some forms of earliness have less relation than others to the problem of securing a crop. Dates of planting, of opening of the first bolls, or of making the first picking are not the best standards for measuring earliness. Varieties that open their bolls first are not necessarily more productive under weevil conditions.

Such varieties as the King, with very small bolls and short staple, open a few days earlier than varieties with longer staples and larger bolls, even though flowering takes place at the same time. The earlier opening often gives an entirely misleading idea of the value of a variety, especially when the lint is short and sparse so that the cotton works out and hangs down from the bolls. The casual observer would estimate that an early small-boll variety like the King is producing twice as much cotton as a big-boll variety like the Triumph or the Lone Star. But when the precaution of actually weighing the crop is taken the big-boll variety may prove the more productive.

A well-whitened cotton field is a beautiful sight, but the experienced cotton grower knows that such a display is not a practical advantage. The fields look the whitest when the cotton is falling out of the bolls. The loss from falling out is very much greater with the early small-boll varieties, because the lint is too short and too sparse to hold together. Varieties that have the storm-proof habit and retain the fiber in the bolls show less cotton in the field, but often yield more fiber and of better quality. The large bolls and the high percentage of lint are other advantages of the storm-proof varieties.

To have the bolls open a few days earlier is also of very little importance from the standpoint of weevil resistance, for the insects do not injure the mature bolls. The primary object is to produce many bolls in a short time. After the plants have reached the fruiting stage it is of the utmost importance to have the crop set as rapidly as possible before the weevils can breed in such numbers as to infest all the buds and attack the young bolls. In the study of varieties from the standpoint of earliness, the factors that influence the setting of the crop are the chief consideration.

Habits of branching have important relations to earliness. Varieties that produce numerous large limbs at the base of the plant begin to set fruit later than those that produce fruiting branches lower down on the main stalk. Moreover, it is possible by simple cultural expedients to suppress the undesirable vegetative branches or secondary stalks that interfere with the production of an early crop under conditions of rank, luxuriant growth of the young plants. The general tendency of recent years to leave the plants closer together, or only a hoe width apart in the rows, undoubtedly favors the production of an early crop, but a further element of safety in close spacing is secured when thinning is not done too early—that is, not until the plants are at least 5 or 6 inches high and have at least three or four true leaves above the cotyledons or seed leaves, instead of being thinned as soon as the seed leaves have opened.[4]

Cluster varieties, with short-jointed fruiting branches, sometimes appear to have an advantage in earliness, but this is often counter-

[4] Cultural control of branching is made possible by the fact that the fruiting branches that bear the flowers and bolls are entirely distinct from the vegetative branches or secondary stalks which it is desirable to suppress. The system of branch control has been described in the following publications:

Cook, O. F. A new system of cotton culture. *In* U. S. Dept. Agr., Bur. Plant Indus. Cir. 115, p. 15–22. 1913.

——— A new system of cotton culture and its application. U. S. Dept. Agr., Farmers' Bul. 601, 12 p., 2 fig. 1914.

——— Single-stalk cotton culture. U. S. Dept. Agr., Bur. Plant Indus. Misc. Pub. 1130, 11 p., 12 fig. 1914.

Meade, Rowland M. Single-stalk cotton culture at San Antonio. U. S. Dept. Agr. Bul. 279, 20 p., 2 fig., 6 pl. 1915.

Cardon, P. V. Experiments with single-stalk cotton culture in Louisiana, Arkansas, and North Carolina. U. S. Dept. Agr. Bul. 526, 31 p. 1918.

acted by greater susceptibility to the shedding of the young buds and bolls if unfavorable conditions are encountered. To secure varieties less susceptible to shedding would be very important as a means of avoiding weevil injury, much more important, for example, than to advance the date of flowering. Several other considerations might enter into the problem of rapid fruiting. Earliness may be due in some varieties to a more rapid rate of growth, as in the case of hybrids. The rapidity of growth is also connected with hardiness of the seedlings, which enables them to resist unfavorable conditions. The size of the seeds is to be taken into account, for large-seeded varieties usually have more vigorous seedlings. Small-seeded varieties should be avoided, even though they may yield high percentages of lint.[5]

It is not safe to base selection for earliness on dates of flowering, because plants that begin to blossom when very young may fail to grow as rapidly as others that blossom a little later. Early blossoming may be only a symptom of a lack of vigor. Extra-early varieties often attain a precocious maturity in dry weather, while other varieties continue to grow and are able to set a larger crop as soon as enough moisture becomes available. The crop can be set more rapidly if more vegetative growth has been made before commencing to flower. Planted by the side of another, as in a testing block, the later variety might appear to suffer more from the weevils, because it would be attacked by insects that were bred on the early sort. But in actual practice two varieties of cotton should never be planted together.

The distinction between earliness as measured merely by the calendar and earliness measured by the setting of the largest crop in the shortest time has an important bearing upon the prospects of the cotton industry. It opens the way not only to larger yields but also to improved quality. If the weevils were to exclude all but the extra-early small-boll varieties like the King, the inferiority of the lint would involve another injury to the cotton industry in addition to the reduced yield and increased cost of production.

SIMULTANEOUS PLANTING OF COTTON.

In addition to the use of early varieties and of cultural methods that favor a rapid development of the crop, it is important to plant early—that is, as early as may be consistent with the fundamental object of avoiding weevil injury by shortening the crop season. The difficulty is to determine when the cotton ought to be planted to secure the best results, for the same date will not be most favorable in different

[5] Cook, O. F. Danger in judging cotton varieties by lint percentages. U. S. Dept. Agr., Bur. Plant Indus. Circ. 11, 16 p. 1908.

localities or even in the same locality in different seasons. The ideal solution of the problem would be for the members of each cotton-growing community to begin planting on the same date.

If later plantings are to be exposed to extra danger from weevils bred on adjacent early plantings the course of safety will seem to lie in planting as early as possible, even at the risk of having the young plants killed or stunted by unfavorable weather. The loss involved in replanting is much less than the injury that the weevils may inflict. But it is easy to understand that this kind of competition in earliness is not calculated to secure the largest crop for the whole community. While the farmers who plant early may enjoy an advantage over those who plant late, neither class is likely to secure as large a crop as if all the cotton were planted at the same time.

The cotton plant grows only in warm weather and does not recover rapidly after it has been checked by cold or other unfavorable conditions that are likely to occur during the early spring months. To plant the cotton too early, so that it is killed by frost or stunted by cold weather, does not help to secure a rapid setting of the crop. Cotton that has received such a check is often overtaken by later plantings that encounter more favorable conditions and make uninterrupted growth. To have the plants stunted in the early stages, so that their later development is slow and irregular, may involve more loss to the farmer than to have the seedlings killed outright and replanted at a later date.

The advantages that were sought by using very early varieties and by planting very early can be more safely assured if the farmers of each community will grow the same kind of cotton and plant at the same time. In communities that observe no regularity in the date of planting, a part of the cotton is injured by being planted too early, while the rest is exposed to weevils bred on the early cotton. If cotton-growing communities were organized to cooperate in simultaneous planting, it would be unnecessary to plant too early. Seasonal conditions, as well as previous experience, could be taken into account in the final selection of a date by a local committee or expert acting for the community.

Simultaneous planting and uninterrupted development shorten the period of exposure to weevil injury. In this way a whole community can have a protection that even the most careful farmers may be unable to secure unless their neighbors cooperate. Doubtless there are many communities where it would be difficult to obtain united action. But if the advantages were fully understood, it is not likely that many farmers would risk their crops or their popularity in the community by unseasonable planting. With no prospect of benefit to themselves, they would only breed weevils to infest the fields of their neighbors.

In developing an organization for simultaneous planting it would become possible for the community to secure other advantages. If a community would limit itself to one kind of cotton, a superior variety could be grown without being exposed to two of the chief causes of deterioration—crossing in the field and admixture of seed at the gin. In a community that became familiar with a single type, selection could be made more effective. Local supplies of good seed would be appreciated, and the fiber would secure a higher price in the market.[6]

COTTON AFTER WINTER CROPS.

Because of the longer summers in the more southern districts of the cotton belt, greater latitude in the dates of planting would be possible if there could be a general agreement among the farmers of each neighborhood or community to begin planting at the same time. In a region like southern Texas, where the raising of winter crops is an important branch of agriculture, the production of cotton may depend on this possibility of planting rather late, after the winter crops have been removed from the land. This is especially important, of course, in irrigated districts where the land must be made to yield large returns to cover the cost of improvements.

The feasibility of late planting in southern Texas depends very largely on whether other cotton is planted early in the same district or whether there is alive in the fields any overwintered cotton that would provide breeding places for the weevils early in the season. With sufficient isolation from other cotton excellent crops are often secured from fields planted after the middle of May, even in places where the weevils had been very abundant and destructive in previous years. Indeed, the May-planted fields sometimes outyield earlier plantings in the same district.

The possibility that late planting might serve as a practical means of avoiding weevil injuries has often suggested itself, the idea being that fewer of the overwintered weevils would survive to attack late-planted cotton. This plan might be worthy of consideration if the communities were so well organized that measures could be taken to destroy all the cotton plants in the fall and thus prevent the breeding of weevils in overwintered cotton. The danger from overwintered cotton is greatest in the warmer parts of the cotton belt, where other conditions are most favorable for the late-planting idea. The advantage sought by late planting can be obtained in another way, by having the crop gathered early and the stalks uprooted and destroyed, so that the weevils will have no food or breeding places during the autumn months. The insects are weakened before the period of hibernation arrives, and most of them die before the next breeding

[6] Cook, O. F. Cotton improvement on a community basis. *In* U. S. Dept. Agr. Yearbook, 1911, p. 397–410. 1912.

season. For the most of the cotton belt the season is too short to justify any delay in planting after the weather is warm enough to permit the plants to make uninterrupted growth.

HOW CULTURAL METHODS AFFECT THE QUALITY OF THE FIBER.

The improvement of cultural methods in weevil-infested regions has been urged chiefly as a means of securing earlier and larger crops. Little or no attention has been given to the fact that the improved methods make it possible to produce a superior fiber. In reality, the same treatment that is used to protect the plants against the danger of shedding the buds and young bolls is also well calculated to improve the quality of the fiber.

The production of long-staple cotton does not depend alone on the planting of a different kind of seed; to a large extent it is a cultural question. The plants must grow under favorable conditions or even the best varieties will fail to produce superior fiber. The growth of the fiber inside the bolls is affected by external conditions, like other parts of the plant. The extent to which the external conditions may affect the fiber is most conclusively shown by the differences that are often to be found among the different bolls of the same individual plant. Bolls that are developed under unfavorable conditions may have weak fiber not more than an inch long, although other bolls on the same plant may produce strong fiber measuring an inch and a quarter. Indeed, the fibers on the same seed often become very uneven as a result of irregular conditions of growth.

To produce fiber of normal length and strength the plants must have continuously favorable conditions. If the conditions are not sufficiently favorable the lint does not grow so long. If the bolls are opened prematurely, before the lint fibers have attained their full development, the staple is very weak and of little value for manufacturing uses. It is safe to say that many of the variations of quality ascribed to differences in the composition of the soil in reality arise from differences of cultural conditions that affect the supply of moisture available for the plants. Alternate checking and forcing of the plants does much of the damage.

The same precautions of deep plowing and thorough cultivation that are needed to avoid checking the plants and thus causing them to shed their buds and bolls in the earlier stages of growth are also required to bring the crop to full maturity and produce superior fiber. This explains why the improved cultural methods may be expected to improve the quality of the fiber as well as to increase the yield. But for the farmer to secure a practical advantage from this improvement of the quality of the staple, improved varieties of

cotton must be grown, so that the fiber can be sold at an advance over ordinary short-staple prices. Even in recognized long-staple markets it is customary to refuse a premium for any fiber that measures less than an inch and an eighth. Staples from that length down to three-quarters of an inch are all quoted at the same price.

There has been a very general idea that the production of long-staple cotton is restricted necessarily to conditions of climate and soil that exist only in limited areas of the rich, level river-bottom lands of Mississippi and Louisiana. The chief reason why these river-bottom lands appear to be especially suited to the production of long-staple fiber is that they usually afford an adequate and continuous supply of moisture. But there is no longer any doubt that fiber of excellent quality can be grown in many other regions outside the former range of long-staple production. Even in Texas, where the danger of drought is greatest, the present cultural methods often make it possible to grow excellent crops of premium cotton.

EFFECT OF WEEVIL INJURIES ON QUALITY.

The boll weevil is often charged with injuring the quality of the fiber as well as with reducing the yield. These statements usually rest on a misapprehension of the nature of the weevil injuries. In some cases it is true that there is a secondary injury to the crop that may be traced indirectly to the weevil injuries. But unlike many other pests the boll weevil has no directly injurious effect upon the cotton plant as a whole.

With the exception of the occasional gnawing of the leaf buds early in the spring, weevil injuries are limited entirely to the flower buds and young bolls. The flower buds that become infested with weevil larvæ soon drop off, in the same way that they do when blasted by any unfavorable condition of the plants, such as sudden drought or wet weather. There is nothing to show that the loss of the buds by weevil infestation has any effect on the plants other than what might be expected if the buds were pruned off in any other way.

The fact that the flower buds of cotton are so easily affected by other natural causes may explain why they are shed so promptly after being infested by the weevils. The first injury to the buds is often very slight and may have no other effect than to cause the buds to stop growing, but even this is quite sufficient to cause shedding, especially in Upland cotton. Even an increased luxuriance of the plant is likely to cause shedding, perhaps because the branches grow faster than the flower buds.

Not all the weevil-infested buds fall off. Some of the larger ones continue to develop and are able to blossom, though the flowers are

distorted. But normal bolls are often set by such distorted flowers. The buds that escape weevil injury are able to produce entirely normal flowers and bolls. Indeed, the effect on the remainder of the bolls is often distinctly favorable. The few scattered bolls found in fields heavily infested with weevils are often of unusual size. Plants that produce only a few bolls often have better lint than those that ripen a larger crop, because such plants are less severely checked by drought or other unfavorable conditions.

It is only when the pruning off of the buds by the weevils leads to an excessive vegetative development of the plants that the weevils can be said to have an adverse effect on the quality of the fiber. Excessive vegetative growth, whether induced by weevil pruning or by fertile soil and hot weather, leads to the same undesirable results. The growth of too many large limbs or vegetative branches around the base of the plant often interferes with a full development of the bolls that were set on the lower fruiting branches early in the season. When a fruiting branch is shaded too much the bolls either blast and fall off or remain small and open prematurely. The lint of such bolls is short and weak, which is one of the chief reasons why the first picking is often considered inferior.

This form of injury is apparent only in extreme cases of weevil infestation and under conditions otherwise favorable to a luxuriant growth of the plants. Under ordinary conditions, when the plants are able to set even a moderate crop there is no reason to suppose that the pruning off of the later buds by the weevils has any adverse effect on the quality of the product. On the contrary, limiting the number of bolls permits the survivors to grow to larger size and develop longer and stronger lint. Though the boll weevils may reduce the crop, they may help at the same time to improve the quality in the same way that pruning and thinning enable the orchardist to produce larger and more perfect apples or peaches.

BREEDING EARLIER VARIETIES OF LONG-STAPLE COTTON.

That the boll weevil would probably inflict serious injuries upon the long-staple industry of Louisiana and Mississippi was foreseen by this Department several years before those States were invaded by the pest. The so-called Peeler varieties formerly in general cultivation in the long-staple districts have special habits of growth and require a longer season than the short-staple varieties grown in the drier regions of Texas. As early varieties were replacing late varieties in all the weevil-infested districts of Texas it was expected that the same thing would occur farther east. This seemed to portend the destruction of the long-staple industry unless earlier varie-

ties of long-staple cotton could be developed to replace the late varieties.

In the light of later events the importance of securing earlier varieties of Upland long-staple cotton appears even greater than before, for it is now seen that the utility of such varieties is not limited to the regions that formerly produced the long-staple crop. By the use of earlier varieties it is possible to produce long-staple cotton in many regions where the old late-maturing types of long-staple cotton could not be grown. Indeed, it now appears that nearly the whole cotton belt may share the advantage of being able to produce longer staple cottons than were formerly considered possible.

To what extent earlier varieties may make it possible to restore the production of long-staple cotton in the districts that were formerly devoted to this crop is still uncertain. The advance of the weevil into these districts is very recent, but it is already evident that the present extreme scarcity of long-staple fiber can be relieved by increased production in other regions.

Columbia cotton.—The Columbia variety, bred in South Carolina by Dr. H. J. Webber, has given excellent results in many localities in the Southeastern States. The variety was developed from a long-fibered variation of the Russell short-staple variety and has much the same habits of growth as the parent type. It is much earlier and more prolific and has larger bolls and more abundant lint than any of the Peeler varieties. Under favorable conditions the lint of the Columbia cotton attains a length of an inch and a quarter, or even more, and is of excellent quality.

Foster cotton.—Another early long-staple variety, called "Foster," has been bred by Dr. D. A. Saunders in the Red River Valley of northeastern Texas and Louisiana. The Foster cotton was derived from a cross between the Peeler long-staple type and the Texas Big-Boll short-staple type and combines the characters of the parental stocks. It is early and prolific and has larger bolls than the Allen or other Peeler cottons. Excellent results have been obtained from the Foster cotton in some cases, but, as in other hybrid types, the characters are not as stable as could be wished, and no extensive distribution of the variety has been made as yet. Nevertheless, there can be no doubt that the Foster cotton is a distinct improvement in the direction of earliness and fertility over the long-staple varieties formerly grown in the same region. Moreover, when the Columbia cotton was planted in Texas and Louisiana for comparison with the Foster, the latter gave better results. Several bales of the Foster cotton raised in the Clarksville district in northern Texas have been sold, some of it at a premium of 9 cents a pound above the price of middling short staple.

MEADE COTTON REPLACING SEA ISLAND.

Ravages of the boll weevil in the South Atlantic coast region and neighboring States are being met in part by the introduction of a remarkable type of Upland cotton, which has been called Meade in honor of the late Rowland M. Meade, who discovered the variety and bred it to uniformity at Clarksville, Tex. Though having the external appearance and behavior of an Upland variety, the Meade cotton produces a 1⅝-inch or even a 1¾-inch staple of fine, even quality, with very little tendency to shorten the fiber at the base of the seed, which was a serious defect of the "Floradora" and other long-staple Upland varieties of former years. The Meade fiber has sold at Sea Island prices, and in some cases even at a premium, which is justified by the greater uniformity of the stock, while the yields usually are equal to short-staple varieties in the same districts, that is, two or three times as much as Sea Island under weevil conditions.

NEW UPLAND LONG STAPLES FROM MEXICO.

Another early long-staple type of cotton from the Mexican State of Durango has been acclimatized in the United States. A select strain has been bred under weevil conditions in southern Texas and has proved superior to any other long-staple Upland variety with which it has been compared. The plants are early and prolific. The flowers are produced in rapid succession, a very valuable quality from the standpoint of weevil resistance, allowing a crop to be set in a short period. The bolls also open together, so that most of the crop can be picked at the same time. The fiber has brought good prices in long-staple markets, from 2 to 10 cents above the current rates for middling grades of short staple. Excellent crops of Durango cotton have been raised under irrigation in southern Texas, and as a rain crop in central and northern Texas near Waco and Clarksville, in western Tennessee near Jackson, in southern Virginia near Norfolk, in South Carolina near Easley, and in Alabama near Uniontown. The largest production of Durango cotton has been in the Imperial and Yuma Valleys of southern California and Arizona, where hundreds of thousands of bales have been grown under irrigation in the last few years, though the shortage of water has interfered seriously with a full utilization of the variety. Fiber of very high quality has been produced also in the San Joaquin and other valleys, and an increased acreage was planted in the spring of 1920. The Durango has a notable advantage over the Columbia under the eastern conditions in the earlier maturity of the crop, which made it possible to secure bale yields of Durango cotton in southern Virginia, where the Columbia opened only a few bolls before frost.

One very important quality of the Durango cotton is drought resistance. As with the long-staple varieties, drought causes the bolls to open prematurely, but the Durango cotton shows this tendency much less than the Allen, Columbia, Foster, and other long-staple varieties that have been tested in the same experiments. The fiber of the Durango cotton also remains stronger and more even in length than in the other varieties. Even under unfavorable conditions there is no such tendency as in the Allen and other Upland long-staple varieties to shorten the fibers of the lower part of the seed to form the "butterfly" condition.

Another superior new type is known as Acala, from the place where the original stock of seed was secured in southern Mexico. The type is somewhat intermediate in external appearance and behavior of the plants, as well as in length and character of lint, between the Durango cotton and the Texas storm-proof or big-boll type, as represented by the Triumph and Lone Star. Within a few years Acala has become one of the most popular varieties in Oklahoma on account of its drought resistance, early maturity, easy picking, and superior quality of fiber, which often brings a premium of $10 to $15 per bale on account of quality and length of staple, $1\frac{3}{16}$ inches under favorable conditions.

CONTINUED SELECTION TO PRESERVE SUPERIOR VARIETIES.

There is a serious problem in maintaining the seed supply of a superior type of cotton during the period of several years that must elapse before a new type can be brought into general cultivation and reach the stage where local breeders and commercial seedsmen can assume some of the responsibility for maintaining uniform strains. Continued selection is necessary to maintain the superiority of any improved type of cotton.

The breeding of superior varieties of cotton is of no practical value unless the varieties are preserved and used for the production of crops. The crossing of varieties in the field and mixing of seed in gins are frequent causes of deterioration of varieties, but even when such dangers are avoided degenerate variations occur. Unless these are removed by selection, uniformity is lost and the variety "runs out" or returns to the diversity of an unselected stock. The work that is required to maintain the uniformity of an improved strain of cotton by continued selection will pay as well or better than any other effort given to the crop. Select strains not only yield more but secure a higher price from the manufacturer because of the uniformity of the fiber. Experiments justify an estimate of at least a

10 per cent increase in yield as a result of selection, with a still greater increase in the quality and market value.

A study of the causes of degeneration of cotton varieties has resulted in the development of an improved method of selection for preserving the uniformity of superior varieties of cotton. Most of the undesirable variations can be recognized by their vegetative characters and removed before the flowering stage is reached and before there has been any opportunity for the pollen of the inferior plants to cross-fertilize the normal individuals. This was not possible under the old method of deferring selection till the bolls were open at the end of the season.

The practical superiority of the new method rests on the fact that selection is not based on any ideal standard or any complicated system of score-card markings, but on a direct comparison of an actual standard represented by the normal plants of the variety growing in the same field. A farmer who has the necessary familiarity with his variety can recognize and pull out the degenerate plants much more easily in the early part of the season than after the inferior individuals have been allowed to grow to maturity.[7]

FINDING MARKETS FOR SUPERIOR FIBER.

One of the most important aspects of the problem of improvement is to open markets for superior fiber. This difficulty is not serious in regions that were formerly devoted to long-staple cotton, but affects all the rest of the cotton belt. The farmer's ability to raise a superior type of cotton does not completely solve the problem of improvement, for unless the fiber can be marketed at a fair price no advantage is obtained.

Some buyers take an interest in the improvement of local products, but many refuse to risk anything or to put themselves to the slightest trouble to encourage progress among the farmers of the community. Indeed, there are indications that buyers sometimes agree upon a policy of refusing to pay more than ordinary short-staple prices. In one case that came directly to the attention of the Department of Agriculture, local buyers would offer no advance beyond prices of ordinary middling cotton, around 8 and 9 cents, for four bales of Durango cotton. The bales were sent to New Orleans and sold at 19½ cents, giving the farmer more than twice as much for his cotton as the local buyers would offer. While this was doubtless an extreme case, reports that have been received from farmers who have grown the Columbia and other long-staple types show a very wide range of prices.

[7] Cook, O. F. Cotton selection on the farm by the characters of the stalks, leaves, and bolls. U. S. Dept. Agr., Bur. Plant Indus. Circ. 66, 23 p. 1910.

It sometimes happens that the farmer is refused even short-staple prices for superior fiber on the ground that the buyer's customers "do not want this kind of cotton." It may be true, of course, that an unenterprising buyer is honestly unwilling to take the trouble to send a few bales of long cotton to a market where he can obtain an advanced price, but it is natural for the farmer to ascribe a buyer's reluctance to pay a premium to a desire to secure a larger profit from the transaction. As long as the farmer believes that he can not secure a fair price for his crop he has no incentive for planting improved varieties.

Manufacturers who use long-staple cotton have been disturbed, of course, by the recent reduction in the supply of such fiber and are anxious to foster this branch of the cotton industry. Unfortunately, however, the manufacturers seldom have any direct contact with the planters. Very few manufacturers appreciate the advantage that they might obtain by having their cotton bought, or at least inspected, in the field, instead of depending upon samples drawn from bales. The inadequacy of the bale method becomes very apparent when comparisons are made between the opinions of different buyers and manufacturers regarding samples of the same bales of cotton. Either there is a very wide margin of variation in the judgment of the buyers or they are often misled by minor inequalities of the samples. But if the buyer or grader went out into the field and saw for himself whether the conditions and the crop were really uniform, his judgment would have an adequate basis, and at the same time the farmer would have a much more acute interest in the production of high-grade fiber.

The present scarcity of long-staple cotton has led many manufacturers to consider the possibility of undertaking to produce their own supplies of raw material. Some manufacturers have bought cotton plantations with this idea in view. And there are other ways for manufacturers to foster the production of long-staple cotton. Well-organized ginning establishments could have a powerful influence in the organization of communities for the growing of a uniform type of cotton. If farmers knew that the price of their crop would be determined by inspectors who understood the relation of uniformity and cultural precautions to the value of the crop, they would observe the precautions that are considered necessary for securing the best results. That manufacturers would be able in this way to stimulate the production of high-grade cotton and to control the production as well as the ginning of the crop may be inferred from the analogy of the beet-sugar industry. Mr. C. S. Scofield, of the Bureau of Plant Industry, has pointed out the fact that the present organization of the beet-sugar industry is very similar to what would result

if well-equipped ginning establishments were conducted by cotton manufacturers. In contracting with the farmers for their beets the manufacturers stipulate the kind of seed to be used and the cultural methods to be followed and enforce such agreements through inspectors.

CONCLUSIONS.

The boll-weevil invasion will not prevent the improvement of the American cotton crop, but affords additional reasons for such improvement. There is no warrant in fact for the idea that only the earliest and most inferior varieties of cotton can be grown under weevil conditions. While the planting of the extra-early short-staple varieties may be justified as an emergency measure in districts newly stricken by the boll weevil, there is no reason to believe that inferior varieties of cotton will continue to be grown in progressive communities.

The general object of all measures of controlling or resisting the boll weevil is to shorten the period of exposure to the pest; that is, the period between the formation of flower buds and the growth of the bolls beyond the danger of weevil injury. There is nothing to show that the extra-early varieties are able to set a crop more rapidly than superior varieties that do not begin to flower quite so early. While earliness becomes a more important factor than before, there is nothing to indicate that superior varieties are likely to be excluded from cultivation in any section that continues to grow cotton in the presence of the weevils. The weevil invasion should lead instead to a better appreciation of the importance of growing improved varieties.

The more careful preparation and tillage of the land necessary to insure a crop in the presence of the weevils also make it possible to produce a much better fiber than could be grown under the former methods of cultivation. The production of a better quality of fiber is a means of securing higher prices and thus replacing the losses inflicted by the boll weevil. Indeed, the only way to secure full advantage from the improved cultural methods enforced by the weevils is to grow a better kind of cotton and sell it for a higher price.

The improvement of cotton culture under boll-weevil conditions can be greatly facilitated by a better organization of cotton-growing communities. Many advantages could be gained if the cotton growers of each community would unite in the choice of a variety and the date of planting and would follow the same methods of cultivation, selection, ginning, and marketing the crop.

One of the most serious problems in the improvement of the cotton industry is to secure markets for superior fiber raised outside the

former long-staple districts. Where local buyers refuse to pay fair prices for superior fiber the farmer loses the advantage of improvement or is under the necessity of sending his cotton to a long-staple market. But if the farmers of a community can unite in the production of commercial quantities of one improved variety of cotton, they will be able to secure fair prices from buyers or may deal directly with the manufacturers.

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